

Adhesives, Fillers, and Coatings Used with Explosives

Introduction

A vital part of the explosives safety program at Lawrence Livermore National Laboratory (LLNL) is devoted to controlling the use of adhesives, fillers, and coatings used in direct contact with explosives. Proper handling and use of these materials in explosive assemblies is necessary to ensure that

- Interference with explosive performance is kept to a minimum.
- The finished assembly will meet design criteria.
- The materials are compatible with the explosives and will not react.
- Excessive heat is not generated during cure.
- Toxic hazards to personnel are controlled. The adhesives, fillers, and coatings described in this supplement are commonly used

with explosives at LLNL. Section 5.3 of the *LLNL Explosives Handbook* (UCRL-52997) provides additional information concerning the compatibility of materials with explosives. Many other materials have been evaluated for compatibility with explosives but are not included here because they are not widely used. For information about materials not discussed in this supplement, contact the Chemical Sciences Division Office (CSD). They will furnish the technical assistance needed to ensure the compatibility of the materials involved. A copy of any safety information furnished to an adhesives user will be forwarded to the Explosives Safety Group at Site 300 (L-871). Materials not on the approved list contained in this supplement may not be used outside the Chemistry and Materials Science Department facilities at Livermore.

Adhesives and Tapes

Compatibility test results must be used cautiously because the manufacturers of adhesives may “improve” the material without notice. Manufacturing changes in the formulation of an adhesive can render the material incompatible. Adhesives should be applied in thin films as the cure reaction for many of the paste adhesives is exothermic and may produce excess heat in thicker sections. The manufacturer’s recommended procedure for mixing and handling an adhesive should always be followed. Table 1 provides information on the adhesives approved for use with various explosives. Tapes are listed in Table 2. Use of a material that is not listed in Table 1 or 2 requires permission of CSD for the specific application with explosives. Table 3 lists properties of some commonly used adhesives. Changes in adhesive formulations, uses, or procedures must be reviewed by CSD. At Site 300, the addition of explosives to adhesives or fillers must be covered by a Chemistry Job Summary or by an Operational Safety Procedure.

Adiprene LW-520

Adiprene LW-520 is a urethane elastomer that is cured with methylenedianiline (MDA). When used in place of pure MDA, a polymeric MDA such as Tonox increases working time (see Table 4). The best mixing ratio is 10.6 parts by weight of Tonox for 100 parts by weight of Adiprene LW-520.

Mixing

The Tonox should be melted (see “Handling Precautions” below) and cooled to 30°C. Then it is added to the LW-520, heated to 35°C, and mixed thoroughly. Use a clean polyethylene cup for mixing to preclude moisture in the material. These melting and mixing procedures should be followed for all urethane compositions.

Working Time

The time a mixture requires to reach a nonpourable viscosity (100,000 cP) is known as its working time or pot life. Timing begins when the curing agent is added to the mixture. The Tonox/

LW-520 adhesive has a working time or pot life of 30 to 45 min.

Storage

All urethanes, including Adiprene LW-520, must be kept dry. Opened cans must be properly sealed after use to prevent moisture pickup.

Handling Precautions

Adiprene LW-520 contains hydrogenated MDI (a mixture of isomers from the hydrogenation of 4,4'-diphenylmethane-diisocyanate) known as Hylene W. Its toxicity and allergenic properties are not well known; however, it is an isocyanate and should be used with good ventilation. Methylenedianiline is a potent liver toxin found to be carcinogenic when fed to rats on a protein-deficient diet. Because of this, it should be handled according to the guidelines set forth in *Health & Safety Manual Supplement 21.16*, "Safe Handling of Carcinogenic Substances." The handler must also take special care to avoid breathing the methylenedianiline dust; use of a filter-type respirator is recommended. DuPont also suggests the following safety precautions:

- Avoid overheating the MDA. (The melting point of Tonox is 77 to 84°C.)
- Provide a "fail-safe" mechanism for the MDA temperature control that, in the event of an irregularity, will turn off the heating system.
- Provide a pressure-relief system for the MDA vessel to permit pressure dissipation in case of thermal breakdown. This relief system should be oriented so that the venting stream of gases and hot MDA are directed away from any personnel area and, preferably, into an outside exhaust system.
- Have the operators observe the temperature of the MDA system regularly as an added precaution.

Other Urethane Adhesives

Table 1 shows other urethane adhesives (Halthanes and L-315/Polyol). These adhesives should be handled and stored in a manner similar to that used for LW-520/MDA. The manufacturer's data sheets should be available and any precautionary controls should be followed. If data sheets are not available, the urethanes should be considered toxic; the handler should take care to avoid skin contact with and

inhalation or ingestion of such adhesives. Any question about urethane adhesives should be directed to the Hazards Control Safety Team in your area.

Cyanoacrylate Adhesive*

Cyanoacrylate is a monomer that has been modified with a thickening agent and plasticizer to produce rapid and strong bonds between a large number of different materials. It differs from a conventional adhesives because it does not set by the evaporation of a solvent. Heat, excessive pressure, and catalysts are usually unnecessary when this adhesive is used. The chemical change that occurs when a film of cyanoacrylate is pressed between the surfaces of two potential adherents results in a strong bond without an appreciable change in volume.

CAUTION: Do not use a cyanoacrylate adhesive joint as the sole support for holding an explosives charge if the bonded joint is under shear or tension. Even with this restriction, cyanoacrylate adhesive is used quite extensively in the trim and assembly of explosives components in hydro and device shots.

Application

Cyanoacrylate adhesive may be applied by means of a clean medicine dropper or with a glass rod or similar tool. It should not be brushed or rolled onto a surface before bonding because the pressure used to apply the adhesive might cause partial polymerization on the surface of the adhesive monomer, thereby rendering the adhesive useless. After the adhesive has been spread over the mating surface in contact with the adhesive-coated surface, apply manual pressure until the bond has set (usually a few seconds).

Cyanoacrylate acts like a pressure-sensitive adhesive and will adhere only when a thin layer or film is pressed between two surfaces. It cannot be used for gap filling or in areas where the surfaces being bonded do not mate. The success of an cyanoacrylate bond depends on the tolerance between the surfaces being bonded. Thus, smooth surfaces that have intimate contact are more readily bonded. When intimate contact is found, setup time or polymerization will take place almost instantaneously. A thickening agent must be used when the parts to be bonded do not mate, or have rough surfaces or voids up to 0.25

mm (0.010 in.); the addition of Santocel-54 to increase adhesive viscosity to 300 to 500 cP will make a good bond possible. When thickened cyanoacrylate is used, a catalyst such as phenylethylethanolamine should be added.

Add the catalyst by mixing 5 to 15 parts by weight of catalyst to 100 parts by weight of acetone. Then paint the catalyst solution on the surface of the inert material (not the explosive), apply the cyanoacrylate to the mating surface, and assemble. Setup of the adhesive may take as long as 10 s, depending on the materials being bonded and the amount of catalyst used. Avoid the use of excessive adhesive; any excess that oozes out will dissolve the explosive in that area.

A cyanoacrylate bond is brittle, and the shock caused by thermal expansion of the adherents may break the bond. The addition of 5% by weight of dimethyl sebacate to cyanoacrylate will help eliminate the brittle bond joint without lowering the strength of the bond.

CAUTION: Do not use cyanoacrylate on uncased detonators or tetryl pellets because it acts as a solvent and will distort the dimensions of the detonators. If the adhesive will not set up properly, it probably has an excess of inhibitor. To correct this do one of the following:

- Leave the cap off the container for a few hours to allow the sulfur dioxide released by the inhibitor to escape.
- Purge the adhesive with dry nitrogen.
- Stir the adhesive gently while it is under a slight vacuum.

Working Time

Set time varies from 5 s to 1 min, depending on the material being bonded. For all practical purposes, a maximum working time of 5 to 25 s is all that can be relied on. The adhesive will not reach its ultimate tensile strength until aged for 24 to 48 h at room temperature.

Storage

Store the adhesive in a closed container in a cool place. The closed container will keep the moisture in the air from reacting with the adhesive. Under ideal conditions, the adhesive will have a shelf life of up to two years.

Handling Precautions

Avoid spilling the adhesive; it adheres tenaciously to skin, clothing, and furniture. If skin contact occurs, flush the affected area immediately with water. The solid that results

will usually wear off during the course of a day without producing ill effects or skin irritation. Cyanoacrylate is also a mild lachrymator (tear producer). Keep it away from the eyes and mucous membranes and use it only in areas with good ventilation.

DuPont 4684

DuPont 4684 adhesive dries to a pressure-sensitive surface serviceable from -50 to 250°C. It is ideal for bonding Teflon, rubber, Mylar, polyethylene, silicone-glass laminates, and metals when a high tensile strength is not required.

Application

Brush the adhesive over both surfaces to be bonded. Allow the solvent to evaporate for approximately 30 min until the adhesive gets very tacky. Then press the surfaces together.

To cut the 30-min solvent evaporation time about 90%, gently play dry compressed air, at a pressure of 30 kPa (5 psi), over the open surfaces of the adhesive. Take care not to let the air ripple the adhesive surfaces. If adjustments will be made after the surfaces to be bonded are placed together, do not allow the full 30-min open time.

Epoxy Resins

Uncured (liquid) aliphatic-amine epoxy-resin systems are not compatible with most explosives and propellants. However, aliphatic and/or aromatic-amine epoxy-resins are considered compatible if they are fully cured (e.g., epoxy laminates). Three epoxies have been certified for bonding strain gauges to LX-04, LX-07, LX-09, LX-10, and to PBX 9404: they are BIPAX-2902, EPY-150, and HYSOL Epoxy Patch Kit, #615. Two other epoxy resin adhesives, RESIBOND #907A and #907B have been approved for use with PBX-9404 and TATB.

Fillers and Coatings

Table 4 is a list of the fillers and coatings approved for use with explosives, and Table 5 is a list of some of their properties. In addition, aluminum silicofluoride in a water and polyvinyl alcohol slurry can safely be used as a flasher coating on any Type A explosive. For further information on materials not listed in the tables, contact the CSD Office in Livermore.

Although fillers and coatings are generally much less toxic than adhesives, the manufacturer's recommended requirements for

control of skin contact or ventilation should be followed carefully.

Crack-Detecting Fluids

Food and Drug Administration (FDA) food colorings Red #2 and Green #3 are exceptional crack-detecting fluids when mixed in the following proportions:

	<u>Parts by wt</u>
FDA food coloring (red or green)	0.08
Ethyl alcohol	16.50
Tap water	46.4
Aerosol wetting agent	0.45

Paint the above solution over the suspected crack; then wipe the area clean with a damp Kimwipe or clean cloth. Cracks that are

undetectable by radiography and visual inspection will, on close inspection, appear as very thin colored lines that can be easily photographed. The use of red and green food coloring (red for one test, green for another) will make it possible to determine when cracks occurred if the part is subjected to more than one test. The formula above has proved quite practical because the solution can be easily removed with water from the test piece to reveal cracks. If excess FDA coloring powder is used, the dye will be difficult to remove from the treated surfaces.